Work and Energy and Power (Chapter 6)

Think of a scenario:
3 students

1. holding a stack of books
2. lifting a piece of paper up/down
3. holding a book up while walking sideways

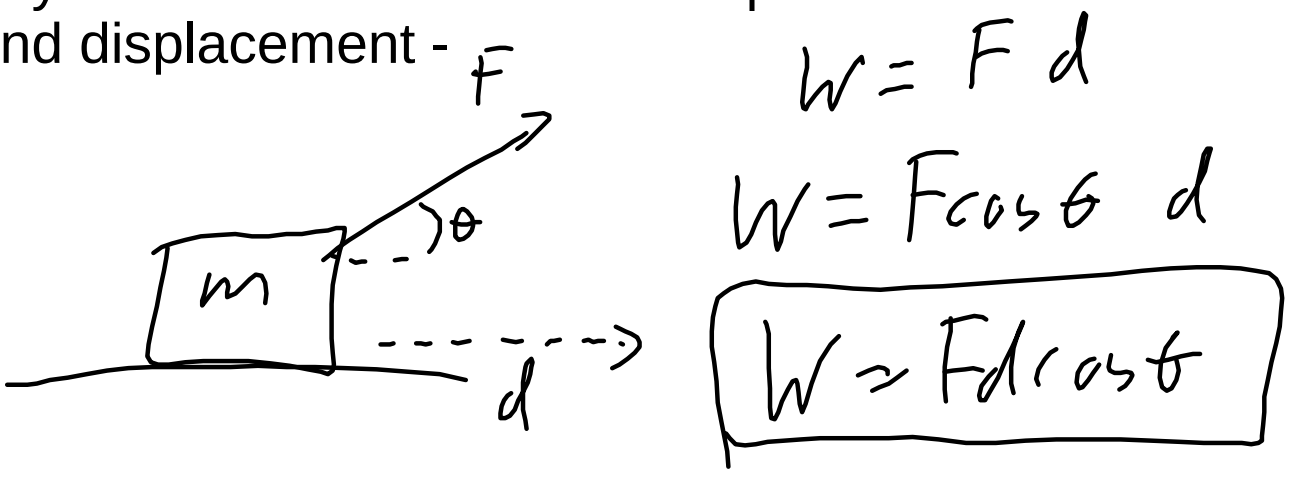
Who is doing the most/least work?

thoughts?

Definitions of work

force and movement

physical work is the vector dot product of force and displacement -



If the component of force in the direction of displacement is opposite the displacement, the work done is negative.

Alternate definition of work: a change in energy

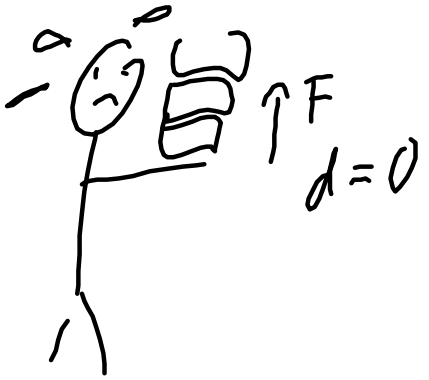
but what is energy?

Energy is the ability to do work. - Work energy theorem.

circular definition - so we use the physical work definition most of the time here.

So, going back to the 3 students:

1.



$W = Fd\cos\theta = 0$

θ

no physical work but biological work.

2

up $W = Fd$

down $W = -Fd$

net work = 0

3

$W = Fd\cos\theta$

90

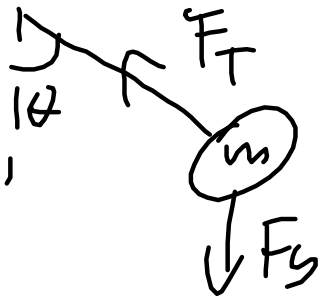
$\cos 90 = 0$

$W = 0$ on the book

eg. 1. A 105kg student runs up 23 stairs 12.0 cm high and 17.0 cm wide in 3.0 s.

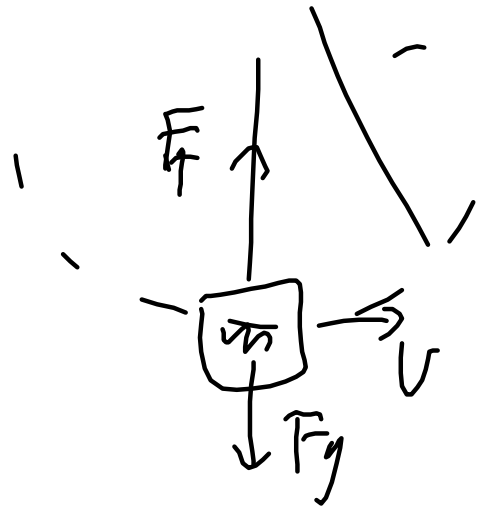
a) how much work is done by the student.
b) how much work is done by gravity
c) how much work is done by the normal force
d) What is the students power, P=W/t
   Watt = 1 J/s or horsepower, 1 hp= 746W
   Work is measured in Joules, J=Nm
   is Work a scalar or vector? a scalar - no direction

2. If you pull a spring sideways with 6.0 N of force it stretches 3.0 cm. If you pull it with 12.0N of force is stretches 6.0 cm. How much work is done on the spring pulling it from 3.0 cm to 6.0 cm? (area under the F-d graph = W)



$$\tan\theta = \frac{F_C}{F_g}$$

F_C = Tangential



$F_C = mg\tan\theta$

$F_C = F_T - F_g$

$F_T = F_C + F_g$

$$\tan\theta = \frac{a}{g} = \frac{4\pi^2 L}{T^2 g}$$

$$T^2 = \frac{4\pi^2 L}{g\tan\theta}$$

$$\boxed{T = 2.0\,s}$$

at ↑ F_N ↓ F_g

$$F_C = \frac{mv^2}{r} = F_N - F_g$$

$$F_N = \frac{mv^2}{r} + mg$$

$$F_N = 0.5kg\left(\frac{20^2}{700} + 9.8\right)$$

$F_N = 4700N$?

$\frac{GMm}{r^2} = \frac{m(4\pi^2)r}{T^2}$

$T^2 \propto r^3$

$T \propto r^{3/2}$

$T^2 = kr^3$

$(1.0)^2 = k(1)$

$T^2 = k(2)^3$

$T_2 = \sqrt{2^3}\, T_1$

Block 2-4
Work, Energy and Power (chapter 6 and handout on universal gravity)
Hand back tests
Term 1 test Friday - omit if it brings your mark down

Think of 3 students:
1. holding a bunch of books motionless
2. lifting a piece of paper up and down

3. a student walking while holding up a book

Which student is doing the most/least work? Why? What is Work?

write down your ideas for 3 minutes and then compare with neighbour.

1. 

$d = 0$ $W = 0$

doing biological work

2 

$W = Fd$ up

$W = -Fd$ down F opposite d

$W_{net} = 0$

3 

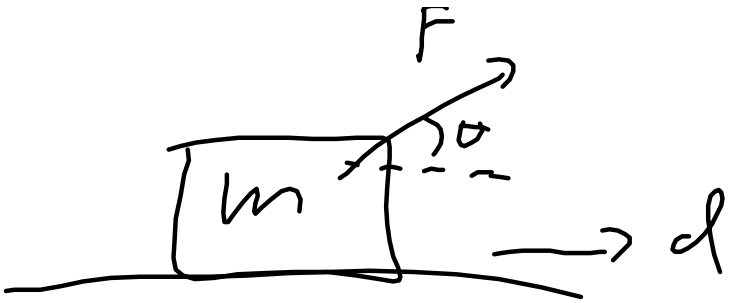
$W = F \cdot d$ vector dot product

$W = Fd\cos\theta$

↑ angle between F and d

$\theta = 90°$

$W = Fd\cos 90 = 0$



$W = Fd\cos\theta$

We have 2 definitions of work:

physical work W is the vector dot product of force and displacement. It is negative if the component of force is opposite the displacement
units: Joule, $J=Nm=kgm^2/s^2$
work is a scalar - no direction

Work can also be thought of as = change in energy - work energy theorem
problem is that the definition of energy is the ability to do work.
So we use physical work as our definition and the work energy theorem to derive energy equations.

Power, P is the rate of doing work.
$P=W/t$
units: Watts, W=J/s horsepower, 1 hp= 746W
scalar

eg. 1. A 105kg student runs up 23 stairs 12.0 cm high and 17.0 cm wide in 3.0 s.

a) how much work is done by the student.
b) how much work is done by gravity

c) how much work is done by the normal force
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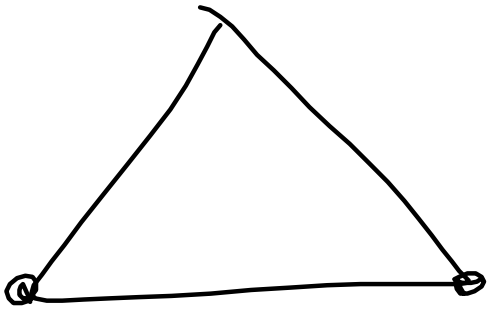
2. If you pull a spring sideways with 6.0 N of force it stretches 3.0 cm. If you pull it with 12.0N of force is stretches 6.0 cm. How much work is done on the spring pulling it from 3.0 cm to 6.0 cm? (area under the F-d graph = W) F_e=-kx where k is the spring or elastic constant



Work, Energy, Power (chapter 6 and handout on gravitational energy)

Scenario:
3 students

1. Holding a stack of books
2. lifting a book up and down
3. walking holding a book

Which of the 3 students is doing the most/least work on the book(s)? why?
definition of work:

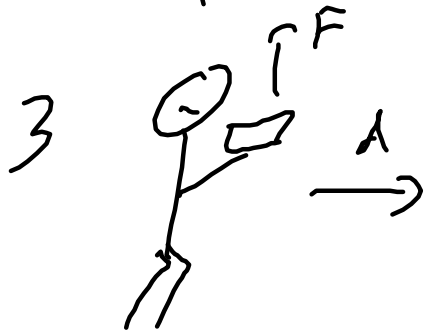
$W = Fd$

$W = Fd = F \times 0 = 0$ (no d)

$W_{up} = Fd$

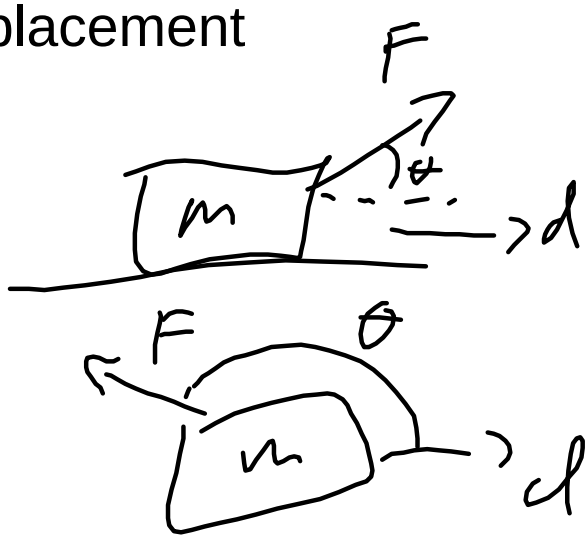
$W_{down} = -Fd$ (F opposite d)

$W_{net} = 0$



$F \perp d$ so $W = 0$

definition:
physical work: the vector dot product of force and displacement



$W = Fd\cos\theta$

negative work if $\theta > 90°$

Work-energy theorem
Work = change in energy

energy is the ability to do work.

units of work and energy: Joules, $J=Nm=kgm^2/s^2$

work is a scalar - no direction even though it can be negative

Power is the rate of doing work or the rate of change in energy.
$P=W/t$
units: Watts, $W=J/s = kgm^2/s^3$
or horsepower, 1hp=746W

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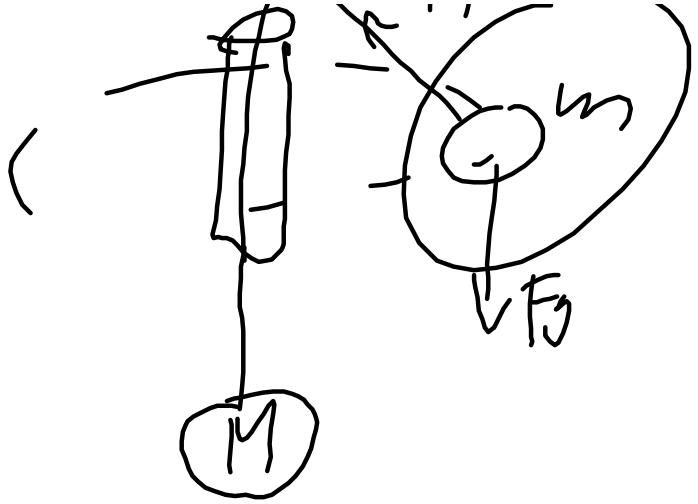
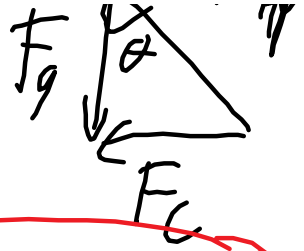
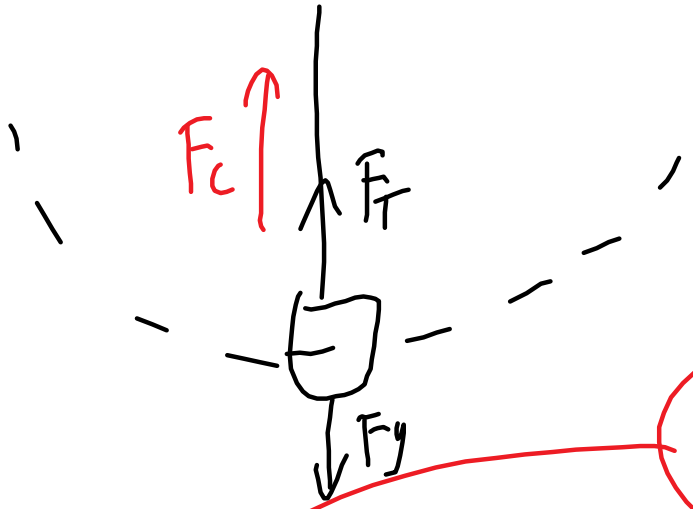




$$\tan\theta = \frac{F_c}{F_g}$$

$$F_c = mg\tan\theta$$



$$F_c = F_T + (-mg)$$

$$F_T = \frac{mv^2}{r} + mg$$

$$T^2 = \frac{4\pi^2 r}{g\tan\theta}$$

$$F_N = \frac{mv^2}{r} + mg$$

$$g = \frac{GM}{r^2}$$

$$\frac{GM_{sun}}{r^2} = \frac{4\pi^2 r}{T^2}$$

$$T^2 = \left(\frac{4\pi^2}{GM}\right) r^3$$

$$K = 1.8^2$$

$$T^2 = K(2)^3$$

$$T^2 \propto r^3$$

$$T = \sqrt{2^3}\, r^{3/2}$$